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(54) **SYSTEMS AND METHODS FOR MERCHANDISE DISPLAY, SALE AND INVENTORY CONTROL**

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G06F 17/00 (2006.01)
G07F 11/00 (2006.01)
(Continued)

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CPC ***G06F 17/00*** (2013.01); ***G06Q 10/087*** (2013.01); ***G07F 9/026*** (2013.01); ***G07F 11/165*** (2013.01); ***G07F 11/32*** (2013.01); ***G07F 11/62*** (2013.01)

(58) **Field of Classification Search**
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USPC 221/6, 13, 127, 129, 130–131, 133, 221/155, 263; 700/232, 236, 242, 243
See application file for complete search history.

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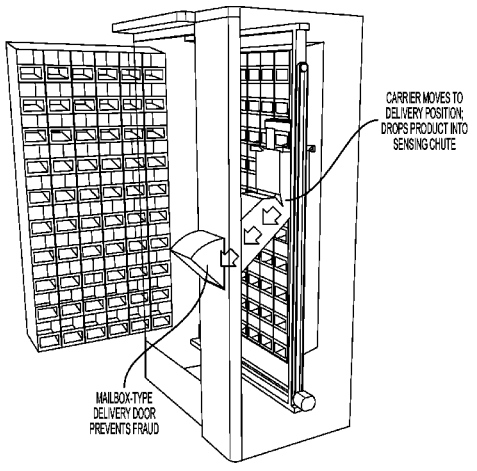
(57) **ABSTRACT**

An automated retail system according to embodiments of the present invention includes a front and/or rear product rack, each rack having a plurality of bins, each of which has a product door, the system further including a basket moveable along an x-y plane on a rail system to selectively open a product door of a product bin to permit the product within the bin to fall into the basket, the basket movable to a product delivery position to release the product from the basket. Such a system may include sensors and/or scanners to determine contents of each bin, such that any product may be placed in any bin, and inventory of each bin or all bins may be determined at any time. The basket may be configured to move in x and y but not z directions, and may also serve as the sole actuation mechanism for opening the doors.

20 Claims, 19 Drawing Sheets



(51) **Int. Cl.**

G07F 11/16	(2006.01)
G07F 11/32	(2006.01)
G07F 11/62	(2006.01)
G07F 9/02	(2006.01)
G06Q 10/08	(2012.01)

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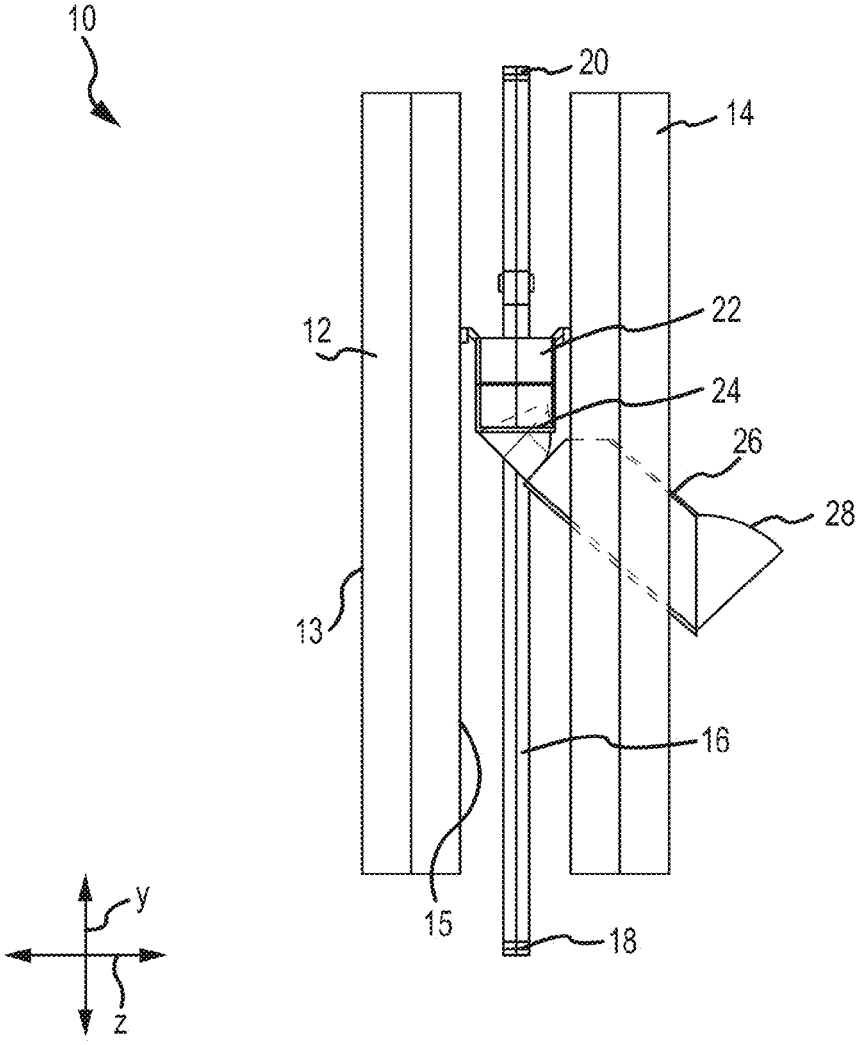

FIG.1

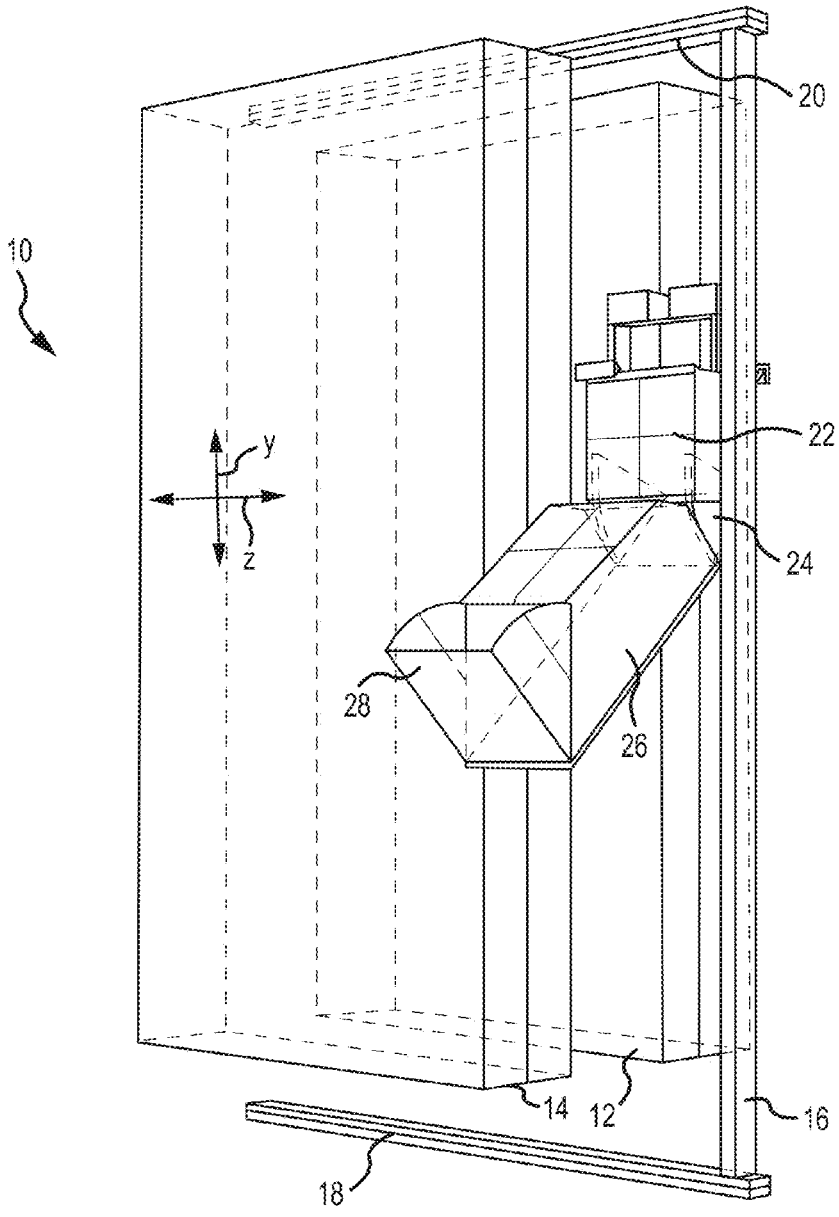

FIG.2

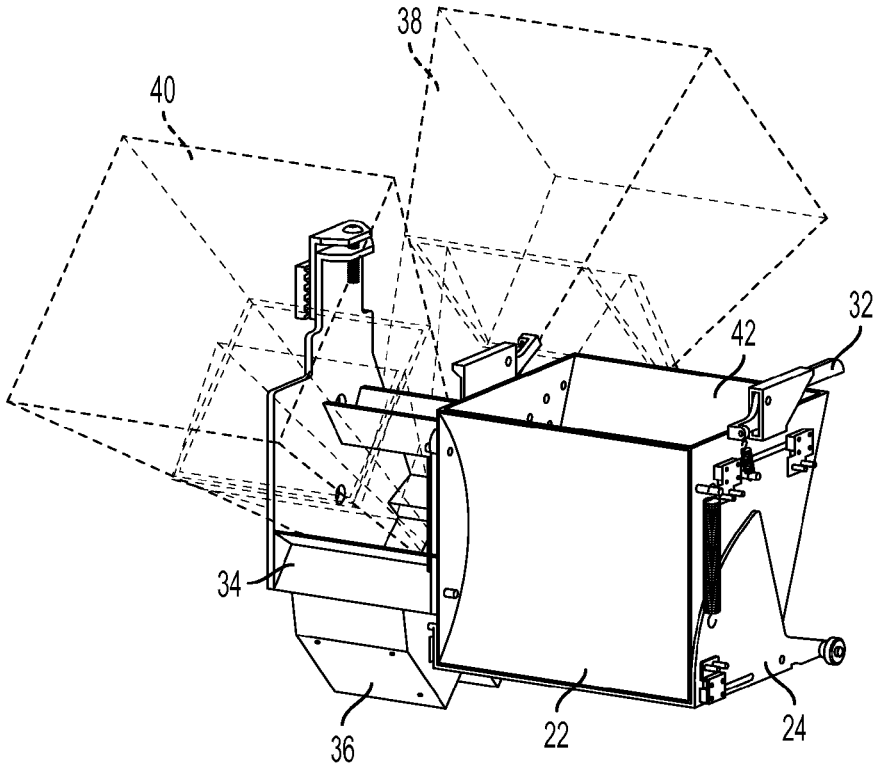

FIG. 3

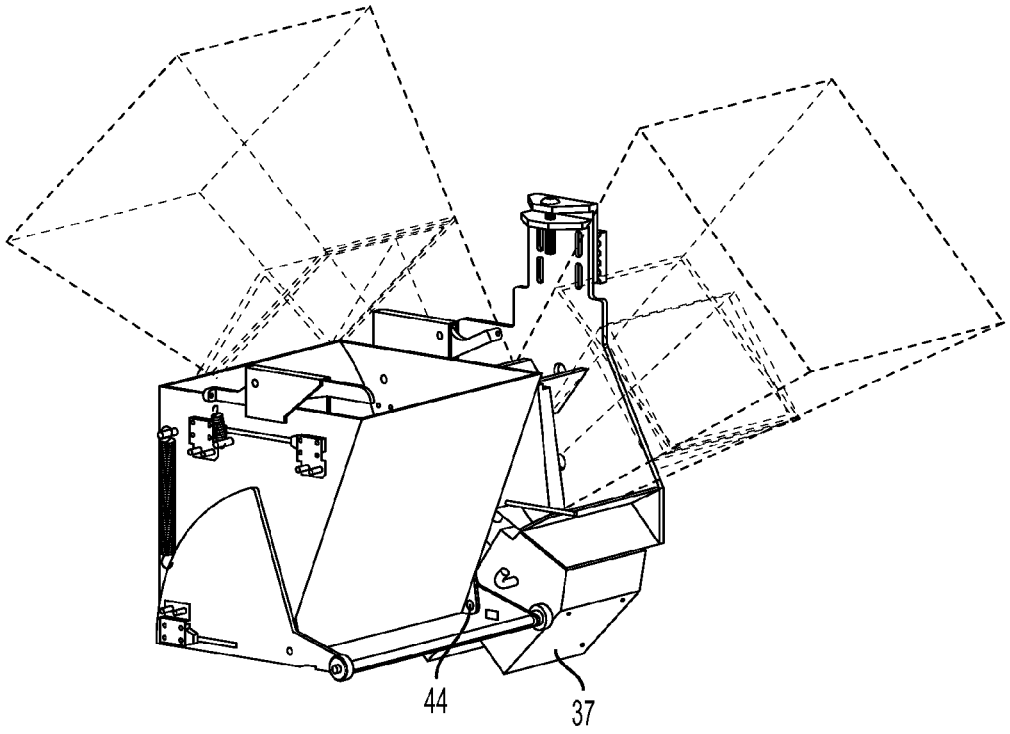

FIG. 4

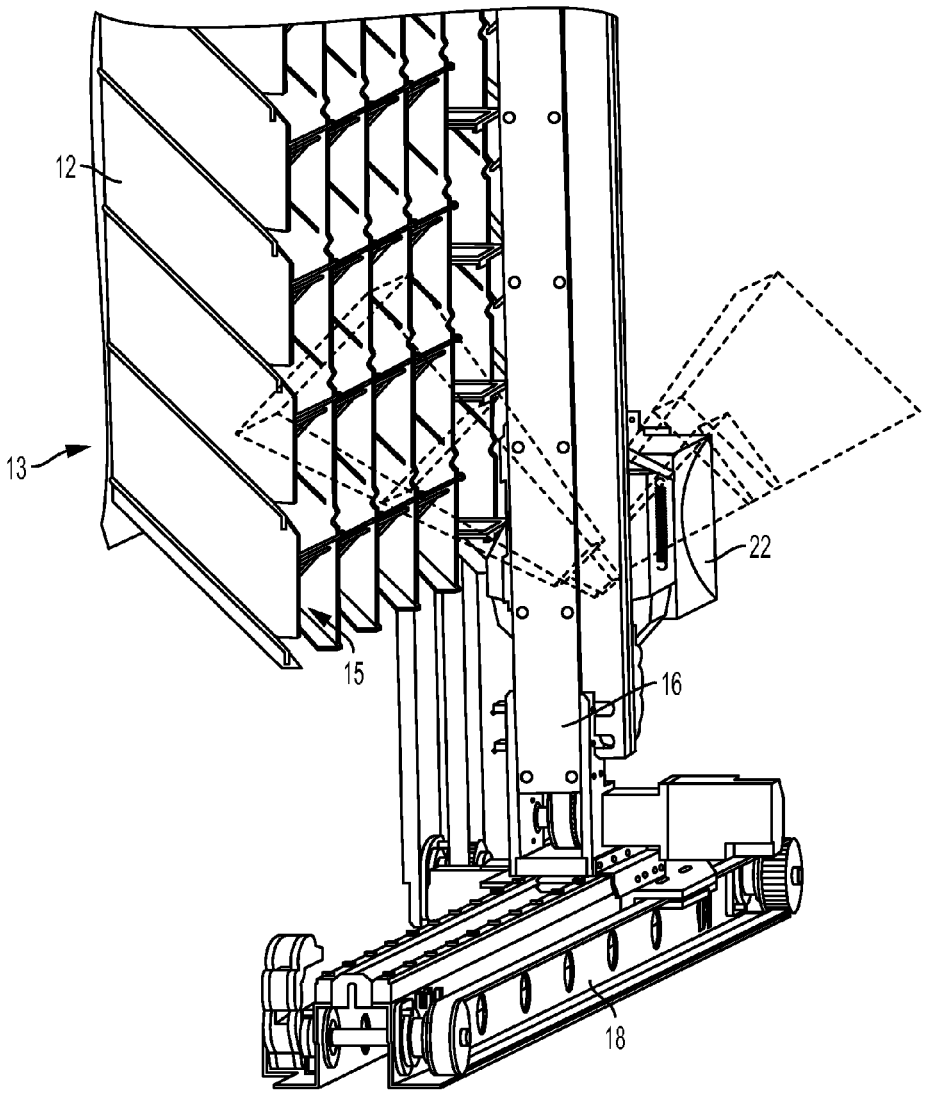

FIG. 5

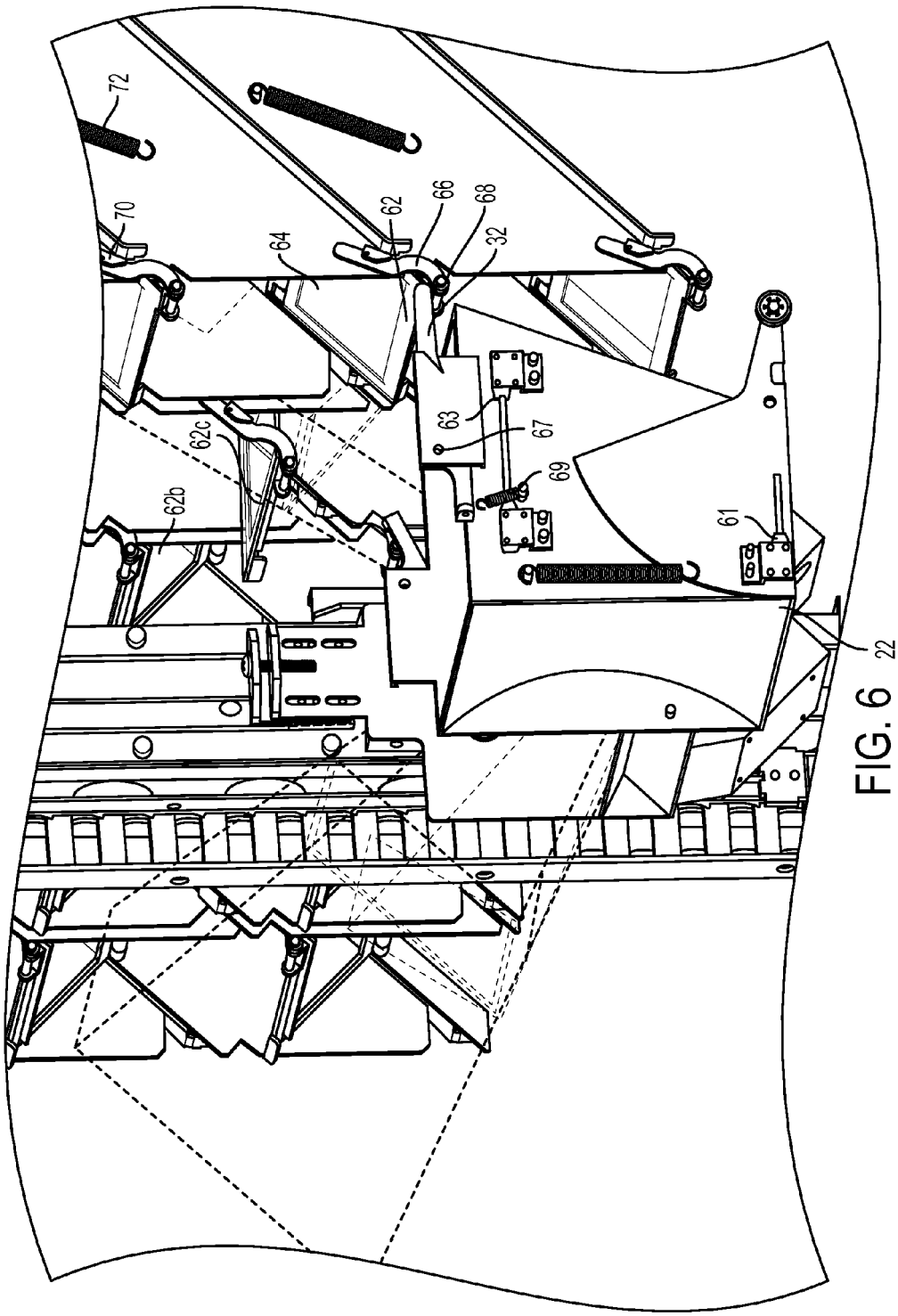

FIG. 6

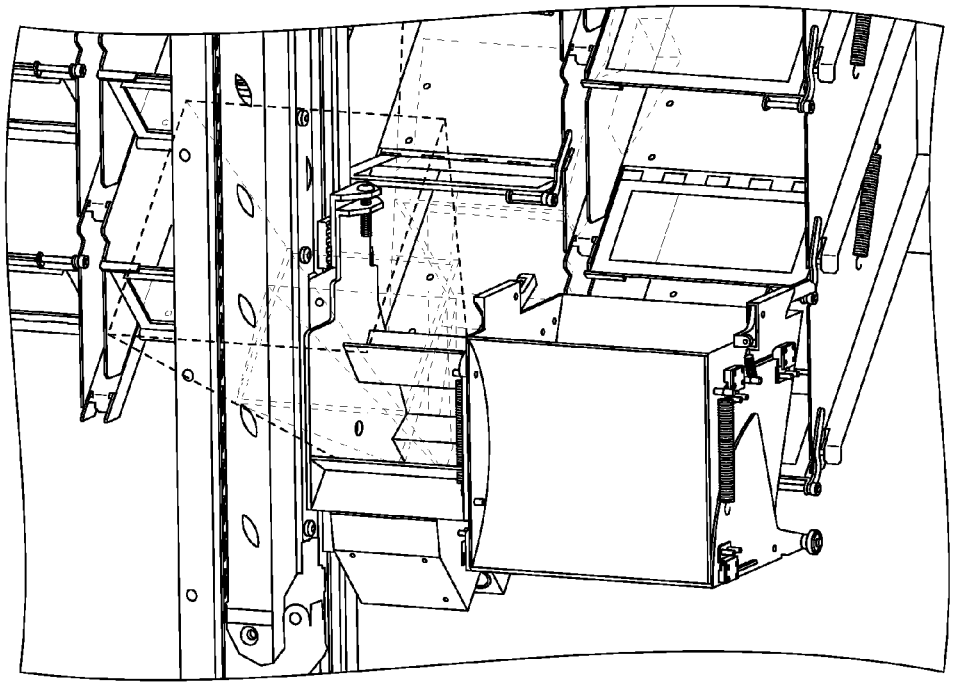

FIG. 7

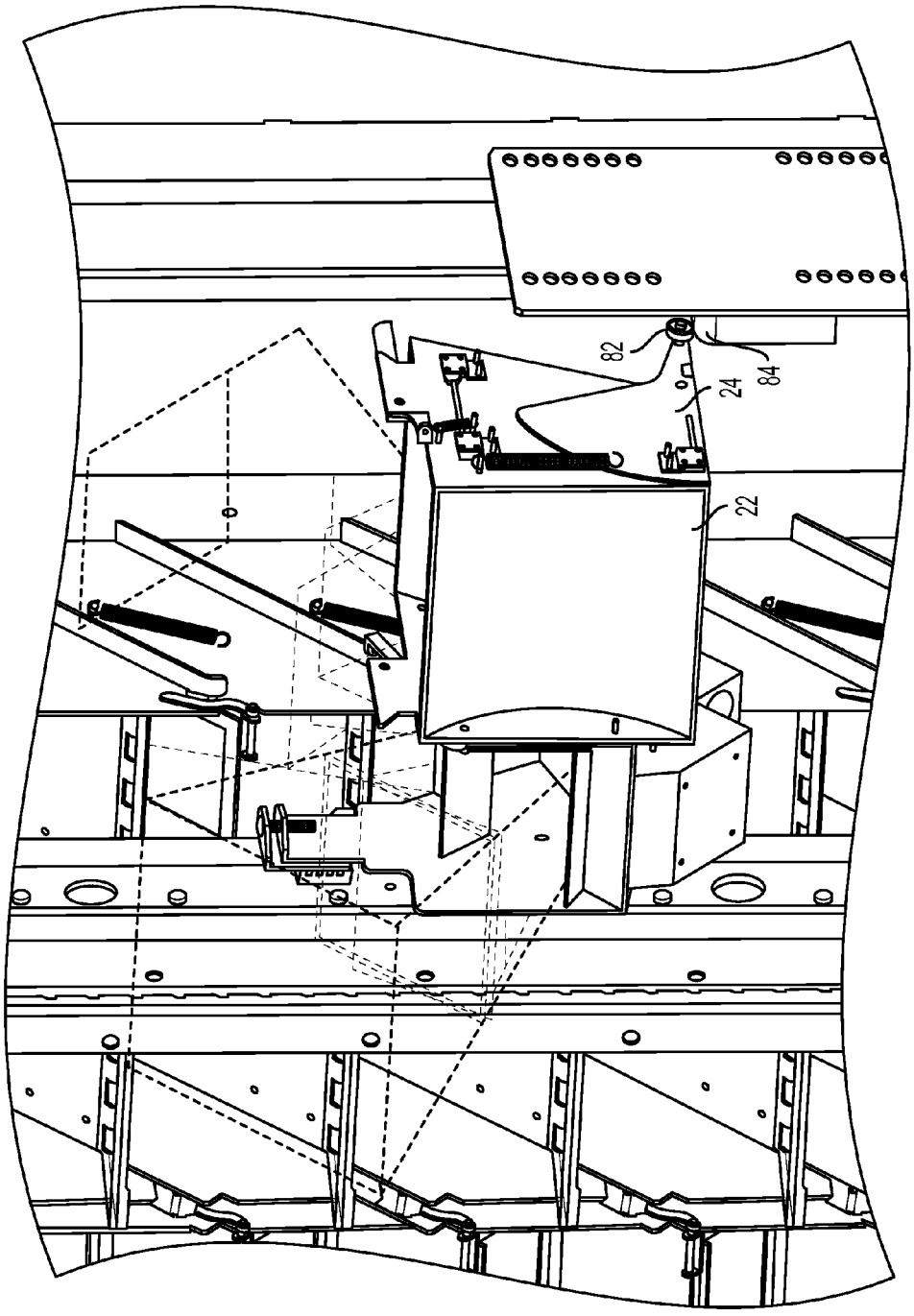

FIG. 8

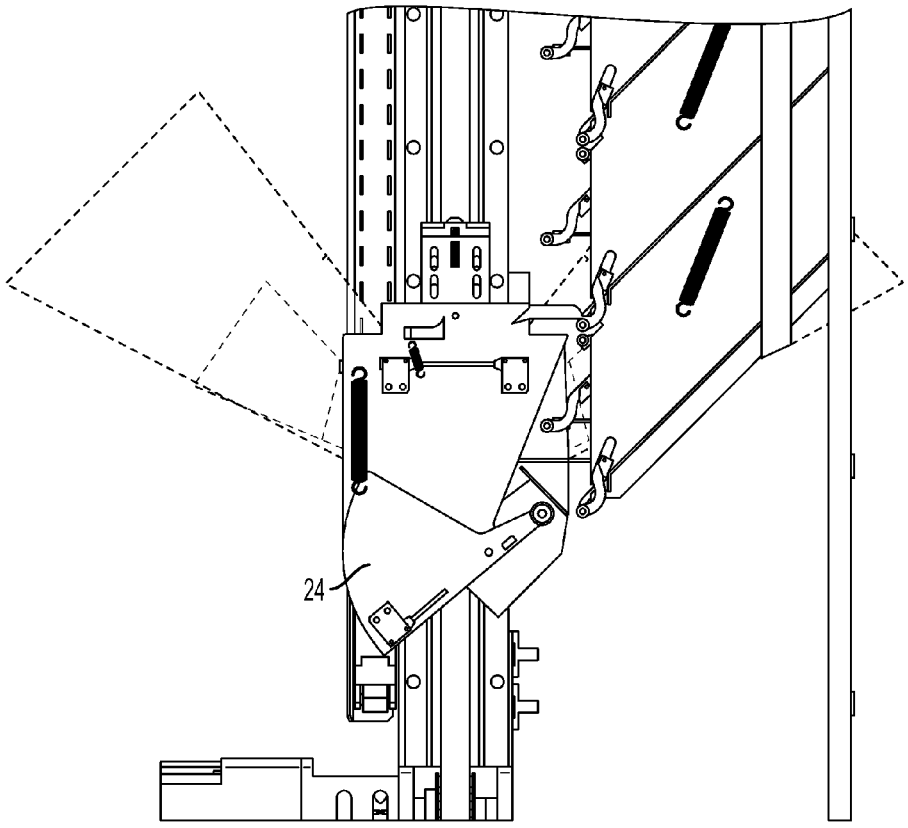

FIG. 9

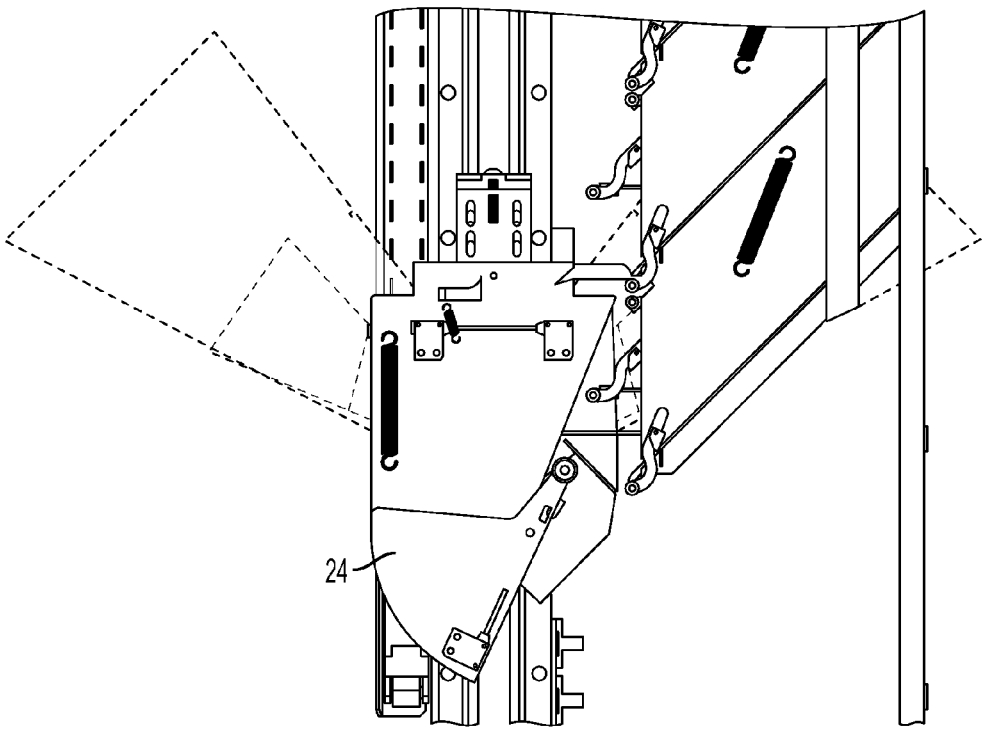

FIG. 10

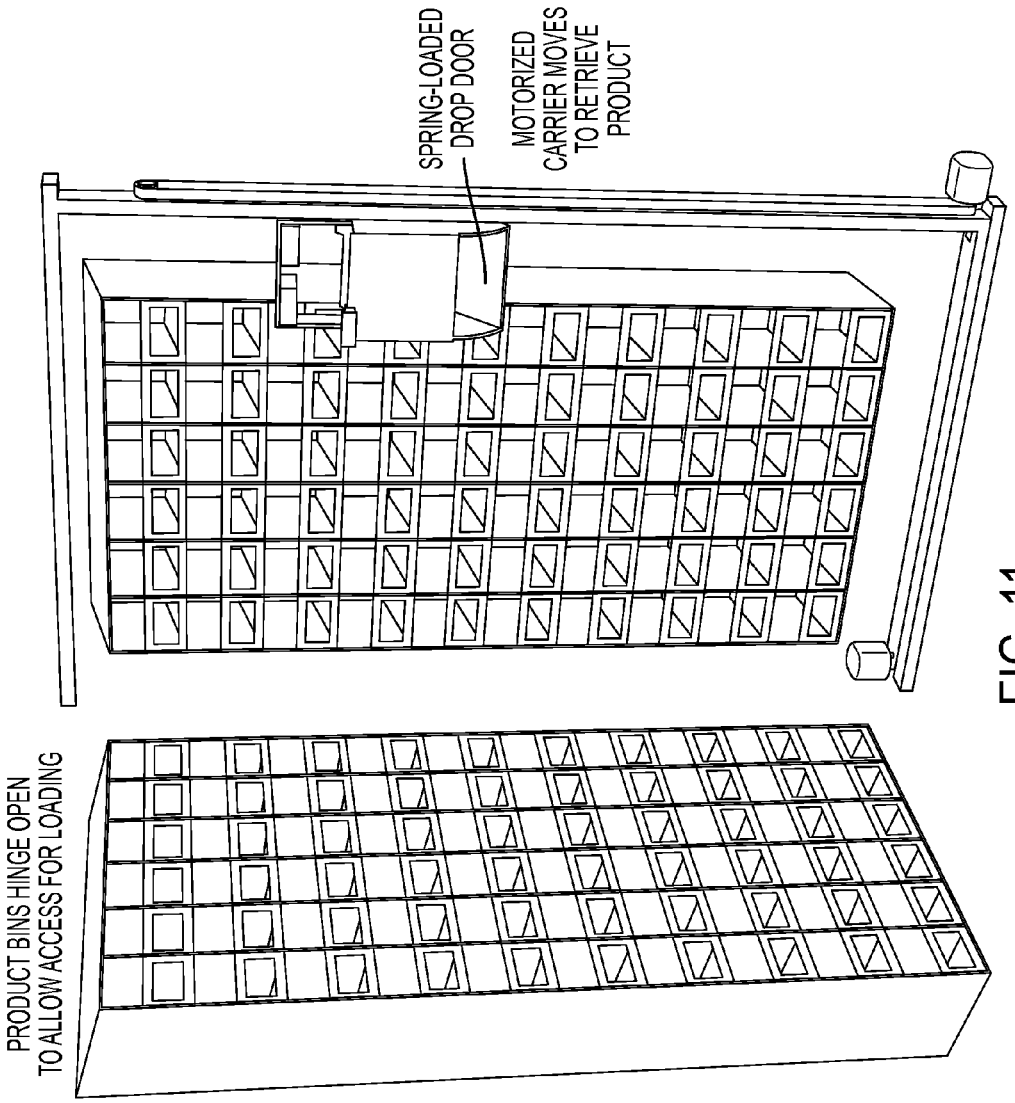
SPRING-LOADED DROP DOOR
MOTORIZED CARRIER MOVES TO RETRIEVE PRODUCT
PRODUCT BINS HINGE OPEN TO ALLOW ACCESS FOR LOADING

FIG. 11

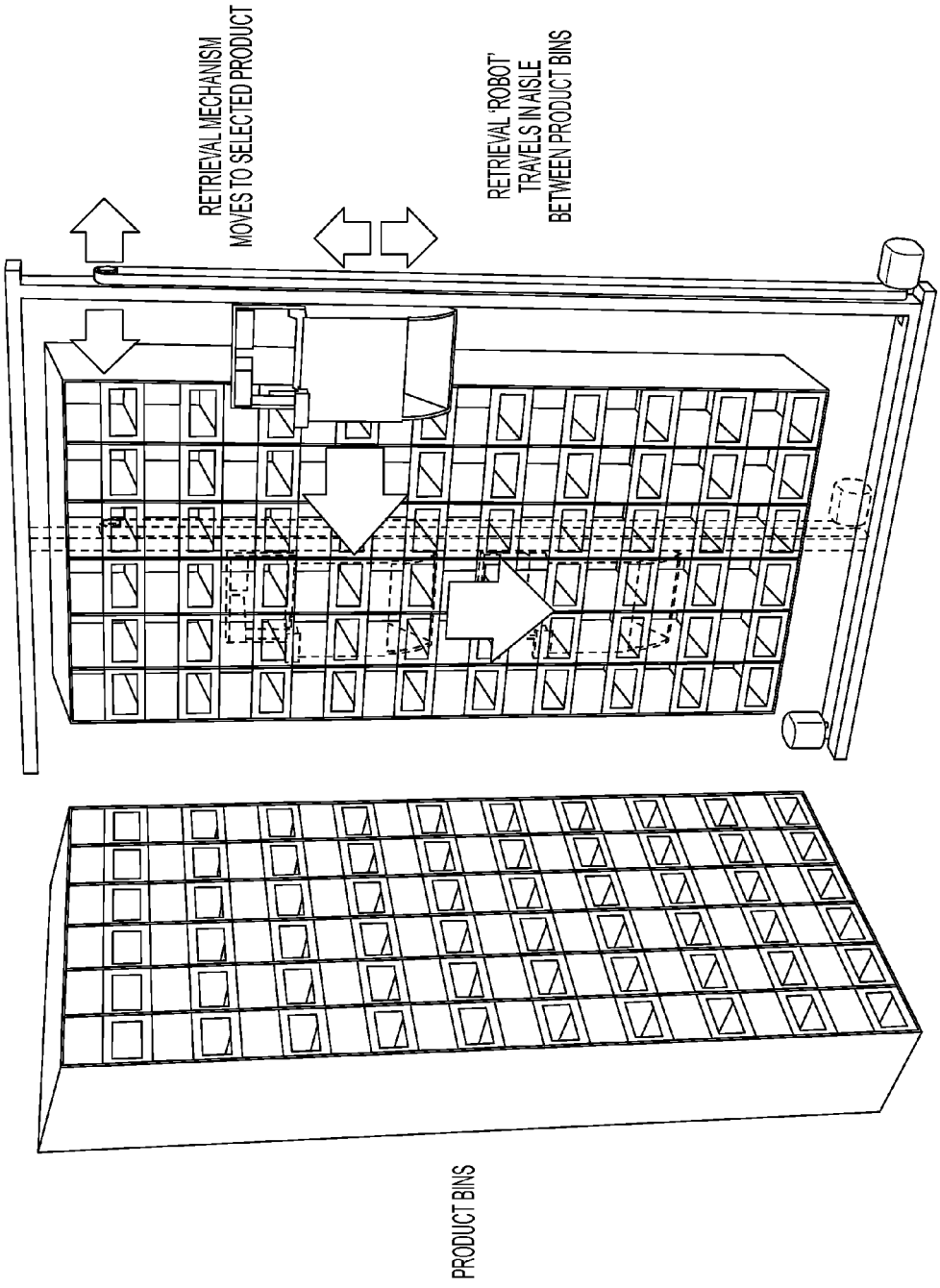
RETRIEVAL MECHANISM MOVES TO SELECTED PRODUCT
RETRIEVAL 'ROBOT' TRAVELS IN AISLE BETWEEN PRODUCT BINS
PRODUCT BINS

FIG. 12

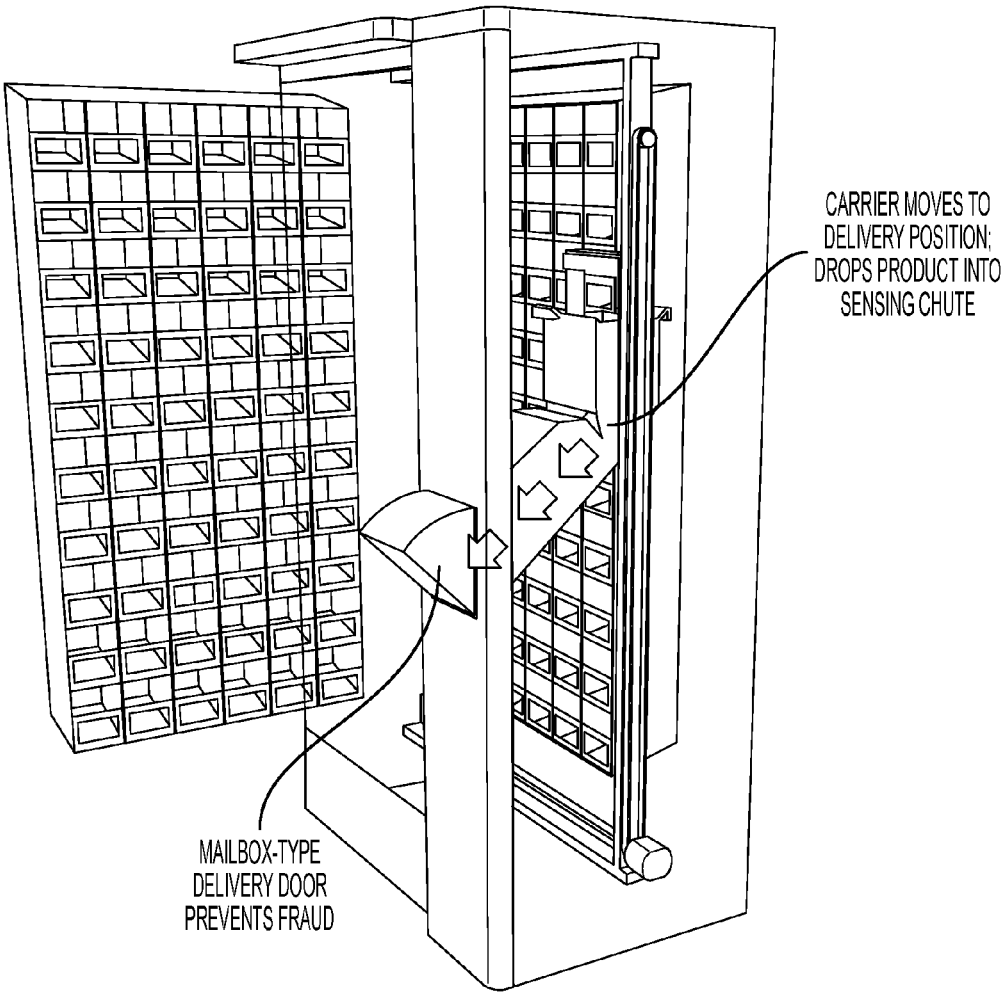
CARRIER MOVES TO DELIVERY POSITION; DROPS PRODUCT INTO SENSING CHUTE
MAILBOX-TYPE DELIVERY DOOR PREVENTS FRAUD

FIG. 13

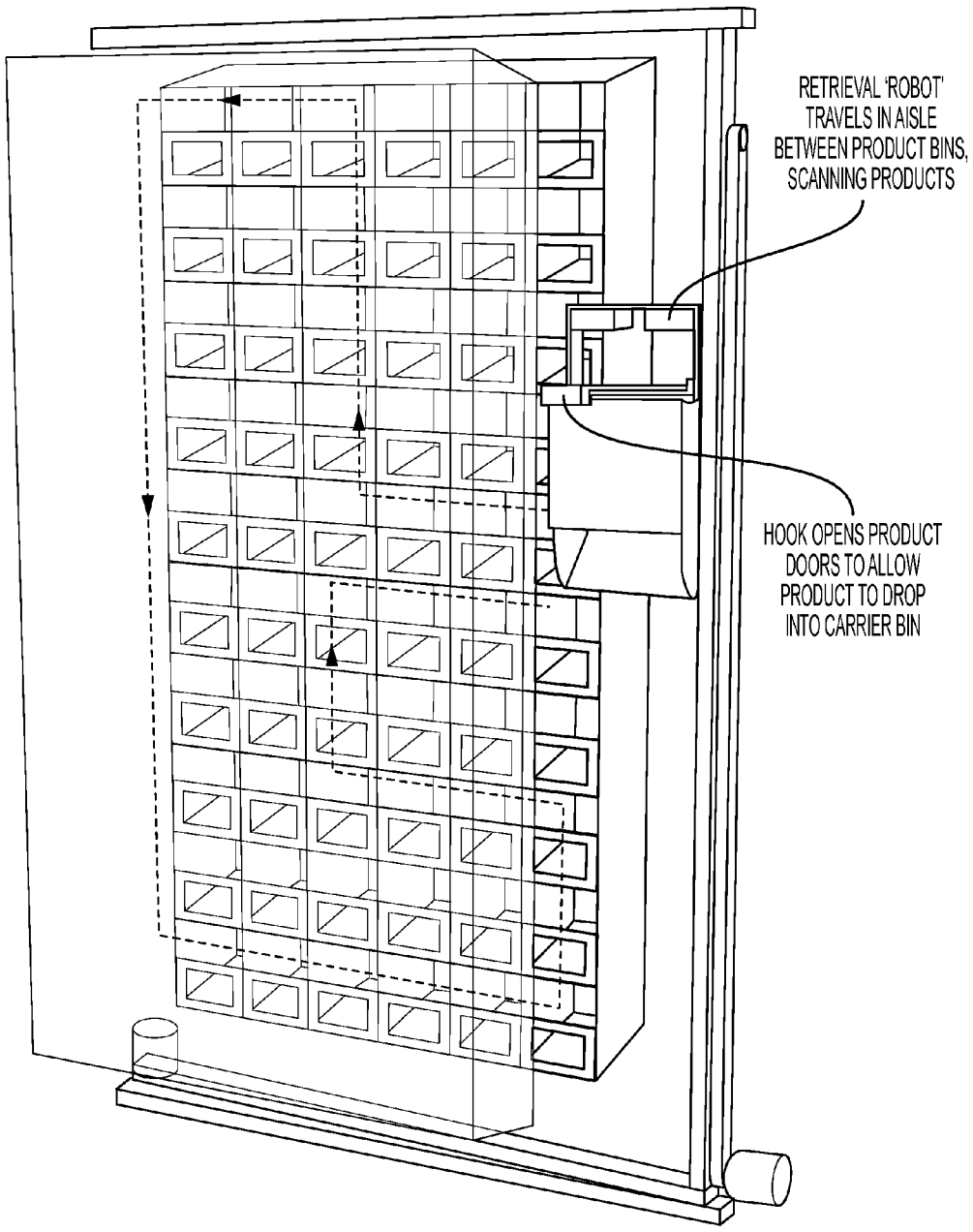
RETRIEVAL 'ROBOT' TRAVELS IN AISLE BETWEEN PRODUCT BINS, SCANNING PRODUCTS
HOOK OPENS PRODUCT DOORS TO ALLOW PRODUCT TO DROP INTO CARRIER BIN

FIG. 14

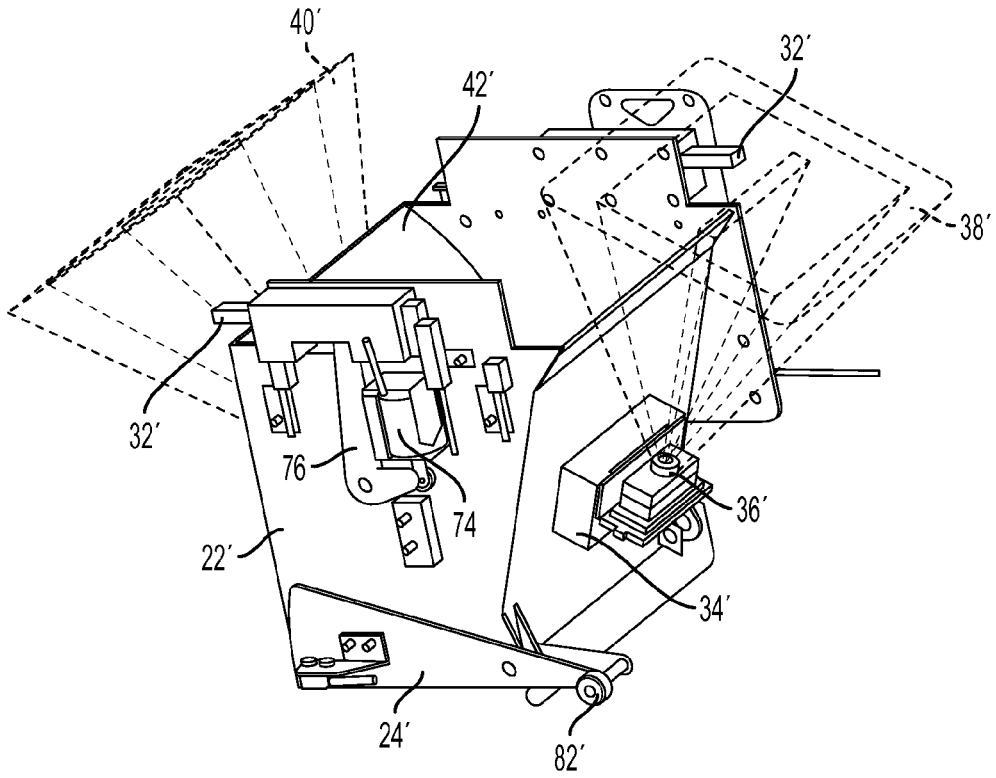

FIG. 15

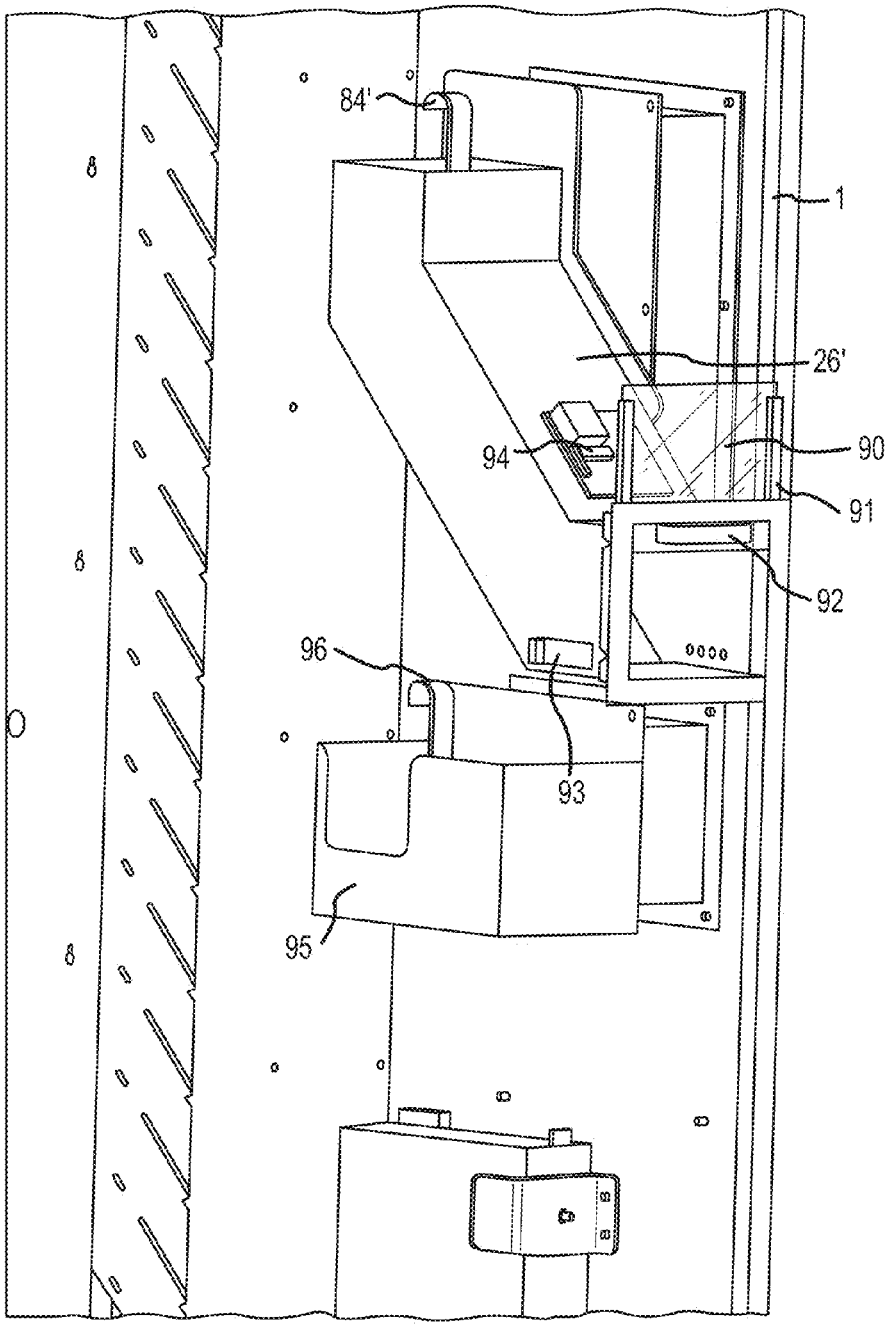

FIG.16

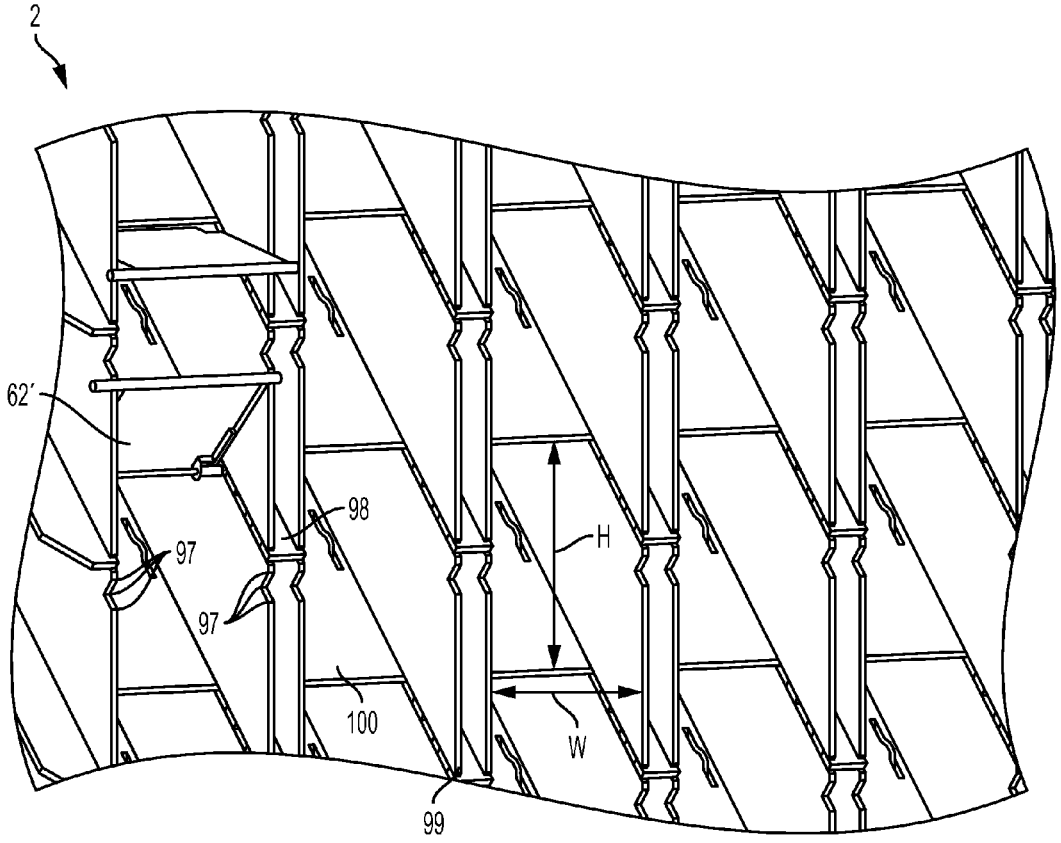

FIG. 17

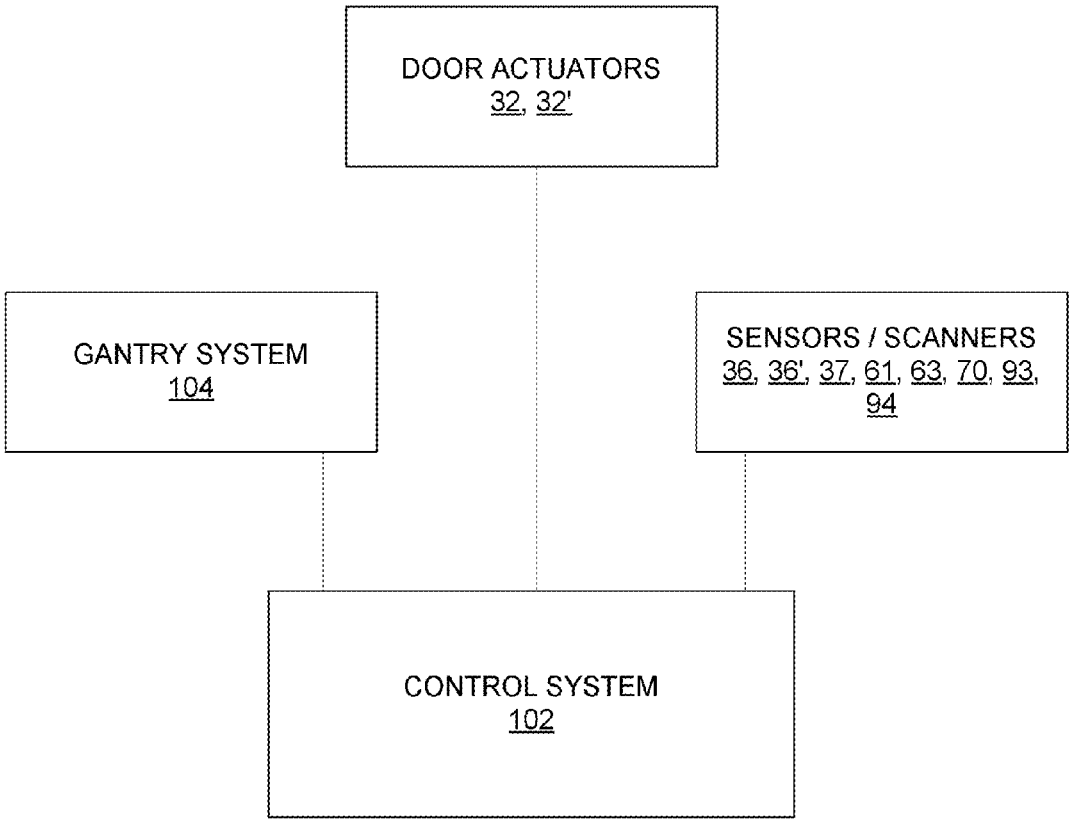
DOOR ACTUATORS
32, 32'
GANTRY SYSTEM
104
SENSORS / SCANNERS
36, 36', 37, 61, 63, 70, 93, 94
CONTROL SYSTEM
102

FIG. 18

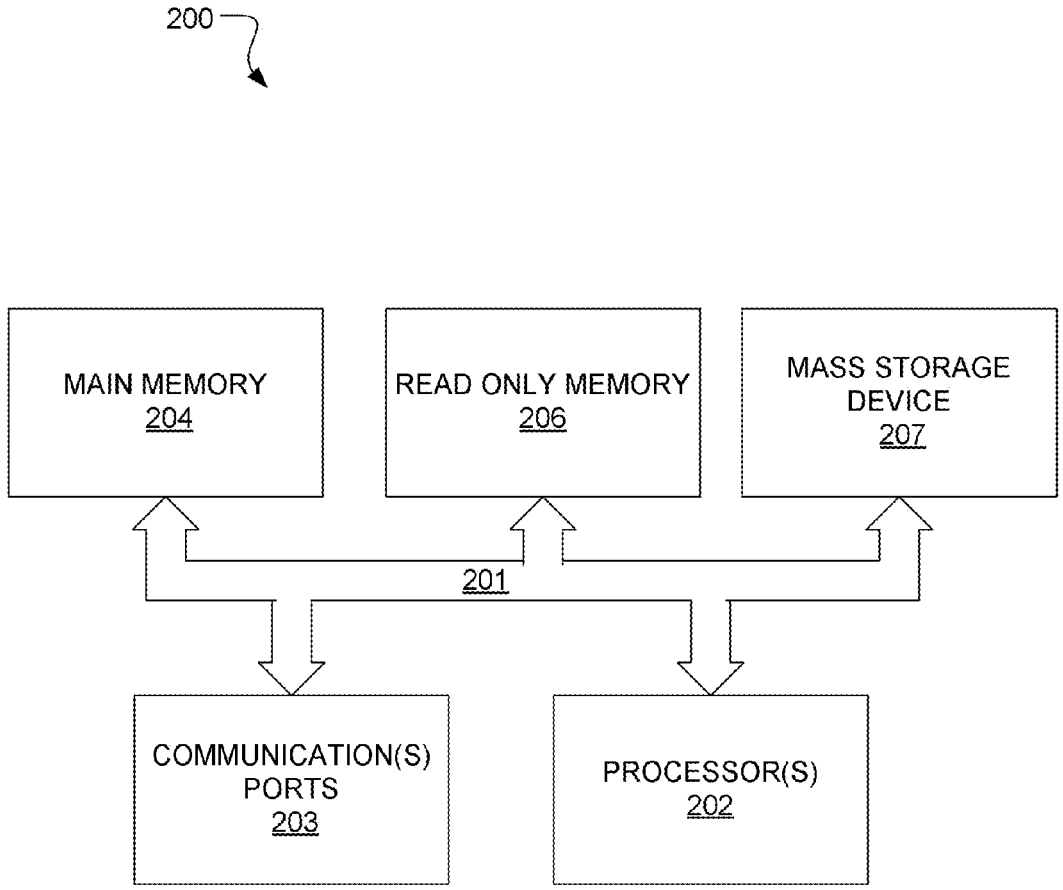
200
MAIN MEMORY
204
READ ONLY MEMORY
206
MASS STORAGE
DEVICE
207
201
COMMUNICATION(S)
PORTS
203
PROCESSOR(S)
202

FIG. 19

SYSTEMS AND METHODS FOR MERCHANDISE DISPLAY, SALE AND INVENTORY CONTROL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/482,555, filed on May 4, 2011, and of U.S. Provisional Patent Application Ser. No. 61/586,628, filed on Jan. 13, 2012, both of which are incorporated herein by reference for all purposes.

TECHNICAL FIELD

Embodiments of the present invention relate to automated vending.

BACKGROUND

Current automated vending systems often do not permit precise control of inventory and sale of particular products within the vending systems. For example, such automated vending systems often require that the vended products be manually placed into a particular arrangement, or that each product be placed into a particular receptacle, and/or that the vending system be programmed or notified, each time inventory is added or subtracted, of the particular receptacle locations corresponding to a particular item or type of item. In such arrangements, precise, automated inventory control is hindered, and risk of inventory anomalies (e.g. unaccounted theft or product damage) is increased. Such systems often operate according to an assumption that the physical presence of the vended items, and their location within the vending system, remains the same from the time the products are loaded into the vending system to the time the products are dispensed from the vending system. For various reasons, this assumption leads to inefficiencies and errors in inventory management, and can often be a hindrance to automated inventory management.

SUMMARY

An automated retail system according to embodiments of the present invention includes a front and/or rear product rack, each rack having a plurality of bins, each of which has a product door, the system further including a basket moveable along an x-y plane on a rail system to selectively open a product door of a product bin to permit the product within the bin to fall or be ejected into the basket, the basket movable to a product delivery position to release the product from the basket. Such a system may include sensors and/or scanners to determine contents of each bin, such that any product may be placed in any bin, and the inventory of each bin or all bins may be determined at any time. The basket may be configured to move in x and y but not z directions, and may also serve as the sole actuation mechanism for opening the doors.

A system for automated retail according to embodiments of the present invention includes a product rack, the product rack comprising a plurality of compartments arranged along one or both of a horizontal axis and a vertical axis; wherein at least one compartment of the plurality of compartments comprises a door configured to open and close the at least one compartment, wherein at least a portion of the door is substantially transparent; a basket; a gantry system, wherein the basket is movably coupled to the gantry system, wherein the gantry system is configured to position the basket adjacent to any of the plurality of compartments by moving the basket along one or both of the horizontal axis and the vertical axis; and a scanner that moves with the basket, wherein the scanner is configured to identify a product within the at least one compartment or to determine that the at least one compartment is empty, and wherein a scanner signal of the scanner is configured to pass through the at least a portion of the door.

The system of paragraph [0005], wherein the basket does not have any component of movement along a direction that is substantially orthogonal to both the horizontal axis and the vertical axis.

The system of any of paragraphs [0005] to [0006], wherein the product rack is a first product rack, the system further comprising a second product rack, wherein the gantry system and basket are situated between the first and second product racks.

The system of any of paragraphs [0005] to [0007], wherein the basket and gantry system are configured to retrieve products from one or more compartments in the first product rack and one or more compartments in the second product rack.

The system of any of paragraphs [0005] to [0008], further comprising a delivery chute.

The system of any of paragraphs [0005] to [0009], further comprising a discard bin.

The system of any of paragraphs [0005] to [0010], further comprising a sensor configured to determine when the product enters the basket.

The system of any of paragraphs [0005] to [0011], further comprising a sensor configured to determine when the product enters the delivery chute.

The system of any of paragraphs [0005] to [0012], further comprising a door actuator, wherein the door actuator is configured to open the door upon movement of the basket along one or both of the horizontal axis and the vertical axis.

The system of any of paragraphs [0005] to [0013], wherein the door comprises a contact element, and wherein the door actuator is configured to open the door when the door actuator is pushed against the door actuator.

The system of any of paragraphs [0005] to [0014], wherein the door actuator is extendable and retractable.

The system of any of paragraphs [0005] to [0015], wherein the door actuator is mounted to the basket.

The system of any of paragraphs [0005] to [0016], wherein the scanner is mounted adjacent to the basket.

The system of any of paragraphs [0005] to [0017], wherein the scanner is mounted on the basket.

The system of any of paragraphs [0005] to [0018], wherein the at least one compartment comprises a bottom that is at least partially sloped, wherein the bottom is configured to permit a product in the at least one compartment to slide out of the compartment when the door is opened.

The system of any of paragraphs [0005] to [0019], wherein a top of the basket is open to receive the product, and wherein a side wall of the basket closest to the product rack is at least partially sloped.

The system of any of paragraphs [0005] to [0020], further comprising a delivery chute, wherein the basket comprises a trap door configured to open when the basket is positioned above the delivery chute.

The system of any of paragraphs [0005] to [0021], wherein the delivery chute comprises a door actuator and the trap door comprises a contact element, and wherein the trap door is configured to open when the contact element is lowered onto the door actuator.

A method for determining size and position of compartments in automated retail according to embodiments of the present invention includes using a gantry system, moving a

scanner along a product rack along a horizontal axis and a vertical axis; recording a horizontal position and a width of each compartment or column of compartments of the product rack along the horizontal axis; recording a vertical position and a height of each compartment or row of compartments of the product rack along the vertical axis; scanning contents of each compartment of the product rack through a door on each compartment that is at least partially transparent.

The method of paragraph [0023], wherein moving the scanner along the product rack along a horizontal axis and a vertical axis comprises moving the scanner along the product rack simultaneously along the horizontal axis and the vertical axis.

The method of any of paragraphs [0023] to [0024], wherein scanning contents of each compartment of the product rack through the door on each compartment comprises scanning the contents of each compartment without opening the door.

The method of any of paragraphs [0023] to [0025], further comprising:

assembling vertical panels and horizontal panels to form the product rack with compartments of desired size.

The method of any of paragraphs [0023] to [0027], wherein scanning contents of each compartment comprises scanning contents of each compartment a first time, the method further comprising scanning contents of each compartment a second time.

The method of any of paragraphs [0023] to [0028], wherein no longer than twenty-four hours passes between the first time and the second time.

The method of any of paragraphs [0023] to [0029], wherein no longer than eight hours passes between the first time and the second time.

The method of any of paragraphs [0023] to [0030] wherein no longer than one hour passes between the first time and the second time.

The method of any of paragraphs [0023] to [0031], wherein the scanning contents of each compartment the second time is performed based on an error message.

The method of any of paragraphs [0023] to [0032], wherein the compartments are restocked between the first time and the second time.

The method of any of paragraphs [0023] to [0033], wherein a bottom of each compartment is provided with a marking, and wherein scanning the marking indicates absence of a product in the compartment.

The method of any of paragraphs [0023] to [0034], further comprising: receiving a request for a particular product; identifying a particular compartment of the product rack in which the particular product resides; and using the gantry system to move a basket to the particular compartment.

The method of any of paragraphs [0023] to [0035], further comprising: opening a door to the particular compartment by moving the basket with the gantry system.

The method of any of paragraphs [0023] to [0036], further comprising: opening the door to the particular compartment by moving a door actuator of the basket onto a contact element of the door; and receiving the particular product within the basket.

The method of any of paragraphs [0023] to [0037], wherein opening the door further comprises: extending the door actuator in a direction that is at least partially perpendicular to the horizontal axis and the vertical axis.

The method of any of paragraphs [0023] to [0038], further comprising retracting the door actuator in the direction.

The method of any of paragraphs [0023] to [0039], further comprising: using the gantry to move the basket to a location over a delivery chute; and releasing the particular product from the basket into the delivery chute.

The method of any of paragraphs [0023] to [0040], wherein releasing the particular product from the basket into the delivery chute comprises: opening a trap door on a bottom of the basket.

The method of any of paragraphs [0023] to [0041], wherein opening the trap door comprises moving a contact element on the trap door onto a door actuator on the delivery chute, using the gantry system.

The method of any of paragraphs [0023] to [0042], further comprising: sensing entry of the particular product into the delivery chute.

The method of any of paragraphs [0023] to [0043], further comprising: sensing a position of the trap door.

The method of any of paragraphs [0023] to [0044], further comprising: sensing a position of the door.

The method of any of paragraphs [0023] to [0045], further comprising: determining that an unexpected number of products have entered the basket; based on the determination, using the gantry to move the basket to a location over an auxiliary bin; and releasing the unexpected number of products from the basket into the auxiliary bin.

The method of any of paragraphs [0023] to [0046], further comprising: receiving the particular product in the basket; and scanning the particular product while it is in the basket.

The method of any of paragraphs [0023] to [0047], further comprising: receiving the particular product in the basket.

The method of any of paragraphs [0023] to [0048], further comprising sensing entry of the particular product in the basket.

The method of any of paragraphs [0023] to [0049], further comprising sensing exit of the particular product from the basket.

The method of any of paragraphs [0023] to [0050], wherein the unexpected number of products is zero products or two products.

The method of any of paragraphs [0023] to [0051], wherein the gantry is capable of moving only along the vertical and horizontal axes.

While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a side elevation view of an automated retail system, according to embodiments of the present invention.

FIG. **2** illustrates a front perspective view of the automated retail system of FIG. **1**, according to embodiments of the present invention.

FIG. **3** illustrates a front perspective view of a product delivery basket, according to embodiments of the present invention.

FIG. **4** illustrates a rear perspective view of the product delivery basket of FIG. **3**, according to embodiments of the present invention.

FIG. **5** illustrates a front perspective view of an automated retail system with a rear product rack, according to embodiments of the present invention.

FIG. **6** illustrates an alternative front perspective view of the automated retail system of FIG. **5**, showing the product delivery basket, according to embodiments of the present invention.

FIG. **7** illustrates an alternative front perspective view of the automated retail system of FIGS. **5** and **6**, according to embodiments of the present invention.

FIG. **8** illustrates a front perspective view of a product delivery basket and delivery door activation mechanism, according to embodiments of the present invention.

FIG. **9** illustrates a side elevation view of the product delivery basket with delivery door partially opened, according to embodiments of the present invention.

FIG. **10** illustrates a side elevation view of the product delivery basket with delivery door fully opened, according to embodiments of the present invention.

FIG. **11** illustrates a perspective view of an alternative automated retail system, according to embodiments of the present invention.

FIG. **12** illustrates a perspective view of the alternative automated retail system of FIG. **11**, according to embodiments of the present invention.

FIG. **13** illustrates a perspective view of the alternative automated retail system of FIGS. **11** and **12**, according to embodiments of the present invention.

FIG. **14** illustrates a perspective view of the alternative automated retail system of FIGS. **11** to **13**, according to embodiments of the present invention.

FIG. **15** illustrates a perspective view of a product delivery basket, according to embodiments of the present invention.

FIG. **16** illustrates a perspective view of an inside of an alternative automated retail system enclosure, showing a product delivery chute, according to embodiments of the present invention.

FIG. **17** illustrates a front perspective view of a product rack for an automated retail system, according to embodiments of the present invention.

FIG. **18** illustrates an automated retail system, according to embodiments of the present invention.

FIG. **19** illustrates a computer system, according to embodiments of the present invention.

While the invention is amenable to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

FIGS. **1** and **2** illustrates an automated retail system **10**, according to embodiments of the present invention. Automated retail system **10** includes a front product rack **14** and a rear product rack **12**, as well as a rail system including a lower horizontal rail **18**, an upper horizontal rail **20**, and a vertical rail **16**. As used herein, the term "vertical" is used to refer to a direction that is substantially parallel to a direction of a gravitational force, and the term "horizontal" is used to refer to a direction that is substantially perpendicular to the direction of the gravitational force. For example, a vertical direction would be a substantially parallel to the y direction indicated in FIG. **2**, while a horizontal direction would be substantially parallel to the x direction indicated in FIG. **2**.

The automated retail system **10** may further include a delivery basket **22** configured to be moved up and down along the vertical rail **16**, with the vertical rail configured to move back-and-forth along the lower and upper horizontal rails **18**, **20**. This rail system, which may also be referred to as a gantry or gantry system, permits the product delivery basket **22** to be moved to any position along the front and/or rear product racks **12**, **14** within the x-y range of motion. Once the delivery basket **22** is moved to the desired position and the product delivery door is opened, the product slides into the delivery basket **22**. The delivery basket **22** is then moved to the x-y position corresponding to the delivery chute **26**, where the basket trap door **24** is opened to permit the product to slide out of the basket **22**, along the trap door **24**, and into the delivery chute **26**, where it may be retrieved through the delivery door **28**, according to embodiments of the present invention.

FIGS. **3** and **4** illustrate front perspective views of a product delivery basket **22**, according to embodiments of the present invention. Product delivery basket **22** includes a basket trap door **24**, which extends under the bottom of the product delivery basket **22** in a closed configuration, and a door actuator **32**, according to embodiments of the present invention. Product delivery basket **22** further includes a sensor mount **34**, to which are mounted two product identification sensors **36**, **37**. Product identification sensors **36**, **37** may be laser-based bar code scanners, camera or imaging sensors, and/or radio frequency identification (RFID) sensors, according to embodiments of the present invention. The superimposed projection cones **38**, **40** are included to illustrate an exemplary three-dimensional range of the sensors **36**, **37**, according to embodiments of the present invention.

FIG. **5** illustrates a front perspective view of an automated retail system with a rear product rack **12**, according to embodiments of the present invention. The product rack **12** includes a number of product chambers or receptacles, which may be arranged into columns and rows, for example. Products may be initially loaded into the receptacles through the back side **13** of the product rack **12**, and then retrieved by the basket **22** from the front side **15** of the product rack **12**, according to embodiments of the present invention. Alternatively, products may be initially loaded into the receptacles from the front side **15**. According to embodiments of the present invention, one product is loaded into each product receptacle. According to other embodiments, more than one product is loaded into each product receptacle.

As shown in FIG. **6**, once the product is loaded into the receptacle, a door **62** prevents the product from falling out of the receptacle. The bottom surface of each receptacle may be sloped or ramped, downwardly from the back of the rack **13** toward the front of the rack **13**, to facilitate product delivery. For example, this slope or ramp of each receptacle permits the product to slide easily into the delivery basket **22** once the product door **62** is opened.

FIG. **6** illustrates one way in which the delivery basket **22** may be used to open a product delivery door **62**, according to embodiments of the present invention. According to embodiments of the present invention, the product delivery basket **22** moves only along the x-y plane, and does not move in the z direction (which is perpendicular to both the x and y directions). This saves cost and expense for building the system **10**, and also simplifies and expedites product delivery. The product delivery basket **22** includes a door actuator **32**. Door actuator **32** may be a rod that extends from the delivery basket **22** toward the product rack **12**; door actuator **32** may be rigidly affixed, and/or pivotably coupled to the delivery basket **22** at pivot point **67** and biased in a downward position by one or more resilient members, for example spring **69**, according to embodiments of the present invention. Accord-

ing to some embodiments of the present invention, door actuator **32** is not extendable or retractable in the z direction.

Each product door **62** includes a door front **64**, as well as a side lever **66** pivotably coupled to the door **62**. A spring **72** may be attached to the door **62** and/or side lever **66** in order to bias the product delivery door in a closed position (as demonstrated by door **62***b*), so that the product is retained within the receptacle by the door **62***b* until the door is opened by the door actuator **32**. Each door **62** may also include a contact element **68**, for example a freely rotating wheel **68**, configured to be contacted by the door actuator **32**. As seen in FIG. **6**, the contact elements **68** extend into and/or beyond the same plane within which the door actuator **32** moves; therefore, the control system which controls the x-y position of the basket **22** is programmed so as not to inadvertently move the door actuator **32** into contact with the contact elements **68**. When a particular item has been selected for delivery, the control system causes the delivery basket **22** to be moved to a position in which the door actuator **32** is directly above the contact element **68** corresponding to the door **62** to be opened, and then the basket **22** (and door actuator **32**) are moved downwardly (in a negative y direction) such that the door actuator **32** pushes downwardly on the contact element **68** to lower the door **62**. The contact element **68** may be a freely rotating wheel, and may include a rubber or other gripping surface to prevent slippage, while rotating to prevent binding as the door **62** is opened, according to embodiments of the present invention. Door **62***b* is depicted in a closed position, while door **62***c* is depicted in a partially opened position, and door **62** is depicted in a fully opened position. The doors directly above and below door **62** are also depicted in an open position, as well as door **62***c* in a partially open position, for illustrative purpose only; during use, normally only one door **62** is opened at any given time by the door actuator **32**, according to embodiments of the present invention.

The delivery basket **22** and door actuator **32** are positioned with respect to each other such that, once the door **62** is opened, the product which was formerly held stationary behind the door **62** then slides over the door **62** (which has been opened to form a downward sloped ramp) and into the basket **22**. As discussed above, the inside **42** of the basket **22** may also be sloped to as to accommodate the downward slide of the released product. After product release into the basket **22**, the door actuator **32** and basket **22** may be raised to permit the door **62** to close (e.g. via spring action **72**), or the door actuator **32** and basket **22** may be moved in a positive or negative x direction to slip the door actuator **32** off of the contact element **68**, according to embodiments of the present invention.

As shown in FIG. **8**, once the desired product has been received into the basket **22**, the basket **22** may be moved along the x-y plane until it is positioned directly above a trap door actuator **84**. The trap door **24** of the basket **22** pivots about pivot point **44** (see FIG. **4**), and includes a contact element **82**, which may be similar to contact element **68** previously described. When the basket **22** is lowered from the position shown in FIG. **8**, the contact element **82** contacts the trap door actuator **84**, and the trap door **24** is opened. FIG. **9** illustrates the trap door **24** in a partially open position, and FIG. **10** illustrates the trap door **24** in a fully opened position. Once the trap door **24** is opened, the product slides or falls by gravity into the delivery chute **26**, and may be retrieved by a user through a delivery door **28**.

According to embodiments of the present invention, each door **62** includes a transparent window **64**, which permits the scanner **36** or scanners, imagers, RFID transceivers, and/or cameras, at any desired time, to move along the x-y plane and take inventory of the automated retail system **10**. This facilitates loading or stocking of the system **10** with new product, and also facilitates inventory tracking and control. When a user manually loads new products into the product rack **12**, the basket **22** moves to positions corresponding to each product bin, and scanning system **36** determines the contents of each receptacle and/or location of each inventory item. This prevents the inventory personnel from having to place certain products in certain locations, and/or having to manually indicate to the system **10** the actual bin location of each product. Optionally, the scanning system **36** may be used to confirm the contents of a particular bin before the door to that bin is opened, and/or to confirm the absence of the contents of a particular bin at any time. The system **10** may also be programmed to automatically scan the inventory at certain time intervals, for example every eight hour period. The system **10** can also make a note of bins for which an inconclusive scan was performed, and create a flag for later follow-up by a technician, and to remove the problem bin from the immediately available retail inventory of the system **10**.

The sensors/scanners **36** and/or **37** may also be used to sense or scan the delivery of a product from the bin into the basket **22**, and/or from the basket **22** into the delivery chute **26**. Other different sensors and types of sensors may also be used for these purposes. For example, each door **62** may include a door position sensor **70** (see FIG. **6**) configured to convey a signal indicating a position of the door **62** to the control system. This may be a simple "open/closed" indication, and/or may include an incremental or relative position of the door, according to embodiments of the present invention. Other optical, camera, imager, laser, and/or RFID sensors may be included in, on, and/or near the basket **22** in order to sense or confirm product location and/or delivery. For example, sensor **63** on the basket **22** may be used to sense the passage of a product from within a bin in the rack **12** to within the basket **22**, and sensor **61** on the trap door **24** may be used to sense the passage of a product from within the basket **22**, down the trap door **24**, and into the delivery chute **26**, according to embodiments of the present invention.

Although a particular trap door **24** mechanism is described herein, other trap door-type mechanisms, as well as other non-trap door-type mechanisms, may be used to retain the product on or within the basket **22** between the time the basket **22** receives the product and the time the basket **22** conveys the product to the delivery chute **26**, according to embodiments of the present invention. For example, the basket **22** may include a bottom which slides out horizontally from under the basket **22** to release a product therein.

Although FIGS. **5-10** illustrate the door opening and product retrieval from the rear product rack **12**, the basket **22** and rail system may also be used to open doors and retrieve products from the front product rack **14** in a similar manner, according to embodiments of the present invention. The basket **22** may include another door actuator extending from the basket **22** in a direction toward the front product rack **14**, similar to how the door actuator **32** extends toward the rear product rack **12**. According to embodiments of the present invention, the vertical and/or horizontal placement of the bins of the front product rack **14** may be offset in an x and/or y direction with respect to the corresponding placement of the bins of the rear product rack **14**, to facilitate movement of the basket **22**. According to other embodiments of the present invention, the bins of the front product rack **14** are not offset with respect to the bins of the rear product rack **12**, and the basket **22** and door actuators **32** are simply maneuvered

around the contact elements **68** of each door to avoid accidental collisions as the basket **22** is moved along the x-y plane.

FIGS. **11-14** illustrate operation of an automated retail system similar to system **10**, according to embodiments of the present invention.

FIG. **15** illustrates a perspective view of a product delivery basket **22'**, according to embodiments of the present invention. Product delivery basket **22'** may include some or all of the features or characteristics described with respect to product delivery basket **22**, and product delivery basket **22** may include some or all of the features or characteristics described with respect to product delivery basket **22'**, according to embodiments of the present invention. Product delivery basket **22'** includes a basket trap door **24'**, which extends under the bottom of the product delivery basket **22'** in a closed configuration, and a door actuator **32'**, according to embodiments of the present invention. Instead of having a laterally adjacent sensor mount **34** like basket **22**, the sensor mounts **34'** of basket **22'** are on the basket **22'** itself, according to embodiments of the present invention. A product identification sensor **36'** is located on the sensor mount **34'**, and a similar product identification sensor may be located on another sensor mount on the other side of the basket **22'**, according to embodiments of the present invention. Product identification sensors **36'** may be laser-based bar code scanners, camera or imaging sensors, and/or radio frequency identification (RFID) sensors, according to embodiments of the present invention. The superimposed projection cones **38'**, **40'** are included to illustrate an exemplary three-dimensional range of the sensors **36'**, according to embodiments of the present invention.

Basket **22'** may operate similarly to basket **22**, according to embodiments of the present invention. According to some embodiments of the present invention, the door actuators **32'** are retractable and extendable, to further facilitate the navigation of the basket in the x-y coordinate system over the various compartments. For example, when the basket **22'** is moved along the gantry system in the x-y directions, the door actuators **32'** may be retracted so that they do not catch on or otherwise interfere with the hardware of the display rack (e.g. the door actuators or the compartments themselves). The door actuators **32'** may be extended when a particular compartment is selected for opening, according to embodiments of the present invention. Although the basket **22'** is shown with two opposing door actuators **32'**, the basket **22'** may alternatively include only one door actuator **32'**, or more than two door actuators **32'**, depending on the arrangement of the front and/or back panels and the particular door opening mechanisms used. The door actuators **32'** may be actuated with an electronically controlled solenoid **74** and pivot arm **76**, or with various other electronically controlled or other mechanisms, according to embodiments of the present invention. Basket **22'** also includes a trap door **24'** and contact element **82'** which operate similarly to trap door **24** and contact element **82**, according to embodiments of the present invention.

FIG. **16** illustrates a perspective view of an inside of an alternative automated retail system enclosure or housing **1**, showing a product delivery chute **26'**, according to embodiments of the present invention. Product delivery chute **26'** and trap door actuator **84'** operate similarly to product delivery chute **26** and trap door actuator **84**, according to embodiments of the present invention. The basket **22'** may be moved to just above the trap door actuator **84'** and lowered until contact element **82'** catches on trap door actuator **84'**, thereby opening the trap door **24'** and causing the dispensed product to fall from the basket **22'** into the delivery chute **26'**, according to embodiments of the present invention. The delivery chute **26'** may include one or more lighting and/or sensing apparatus **93**, **94** configured to identify the receipt of a product at the bottom of the chute **26'** and/or to scan the product at the bottom of the chute **26'** to identify and/or confirm the identity of the product, according to embodiments of the present invention. For example, system **93** may create a light curtain across the delivery chamber which is interrupted when a product arrives. The delivery chute **26'** may include a delivery door **90**, for example a door **90** which slides up and down on tracks **91** and has a handle **92** for lifting the door, according to embodiments of the present invention. According to embodiments of the present invention, the opening of door **90** is locked until a product is ready to be retrieved from the chute **26'**.

FIG. **16** also shows an auxiliary bin **95**. Auxiliary bin **95** may also have a trap door actuator **84'**. Products may be delivered by the basket **22'** to the auxiliary bin **95** in much the same way that they are delivered to the delivery chute **26'**, by positioning the basket **22'** over the door actuator **96** and lowering the basket **22'** until contact element **82'** catches on the door actuator **96**, thereby opening the trap door **24'** and causing any product within the basket **22'** to fall into the auxiliary bin **95**. The auxiliary bin **95** may be used to receive items which have expired, items which require additional attention before being dispensed, and/or items to be disposed of, for example. The auxiliary bin **95** may also be used by basket **22'** to open the trap door **24'** in situations in which the control system for the basket **22'** cannot determine the identity of a particular product and/or cannot determine whether a product is in the basket **22'**. The auxiliary bin **95** may also be used to release products in cases in which the basket **22'** detects or suspects the presence of more than one or of too many products within the basket **22'**, to prevent the dispensation of too many products or unknown products, according to embodiments of the present invention.

FIG. **17** illustrates a front perspective view of a product rack **2** for an automated retail system, according to embodiments of the present invention. The rack **2** includes compartments as described above, with each compartment having a width W and a height H, according to embodiments of the present invention. The rack **2** may be formed of various plates, which may be metal or plastic or other rigid or semi-rigid material. For example, the bottom of each chamber may be formed of a bottom plate **100**, and the sides of each chamber may be formed of vertical plates **99**. A spacer plate **98** may be located between adjacent vertical panels **99**, and may in some cases operate as a stop for the door **62'** when the door **62'** is fully opened, according to embodiments of the present invention. These sheets or plates **98**, **99**, **100** may be used to create compartments which are customizable in size and easy to assemble. As described above, the plates **100** may interface with the vertical plates **99** so as to create a downward slope to permit products sitting on top of the plate **100** in each compartment to slide down over the door **62'** when the door **62'** is opened, according to embodiments of the present invention.

The control system which controls the position of the basket **22** or **22'** uses sensors **36**, **37**, **36'** which may also be configured to identify position or relative position. Using these sensors, the control system can identify the location of a compartment and determine the location of the basket **22** or **22'** relative to the compartment. The sensor system may be configured to identify edges, for example the left-most and/or right-most edges of the vertical plates **99**, which permit the control system to position the basket **22**, **22'** correctly in the x dimension. The sensor system may also be configured to identify one or more edges **97** formed as notches or breaks in

the vertical plates **99**, in order to permit the control system to position the basket **22**, **22'** correctly in the y dimension. As such, the same basket **22**, **22'** and sensor systems may be used with a wide variety of different compartment sizes and configurations. The basket **22**, **22'** and sensor systems may also be used to scan and deliver items from a rack which includes differently-sized compartments on the same rack, using this position identification technology. This also permits the same programming to be used for different rack configurations, thereby decreasing the cost of such systems and making them easier to physically update and/or configure.

According to some embodiments, the sensor system can scan the contents of a compartment while at the same time identifying one or more indicators of the location or boundary of the compartment. According to some embodiments, multiple baskets **22**, **22'** may be used simultaneously or independently for the same or different products racks within the overall system.

The automated retail system may include an initialization sequence or protocol for the control system of the basket **22** or **22'**, according to embodiments of the present invention. The basket **22** may begin in a "home" or starting position, for example in the upper or lower left-hand or right-hand corner of a particular product rack **2**, and may then use the position sensor as the basket **22** moves to the right or left to count the number of vertical plates **99** until it reaches a stop (either virtual or actual), and may also move up or down to count the number of vertical edge indicators **97** until it reaches a stop (either virtual or actual), to create an internal "map" of the location of each compartment. This initialization sequence may be performed upon machine startup, or at regularly scheduled intervals, or when the system detects a fault state or otherwise encounters an error. The scanning of each product in each compartment may be done simultaneously with or at a different time from this initialization sequence. Also, the initialization sequence may be performed for one of the front and back racks and then the other, or alternatively with sensors on both sides of basket **22**, may be performed simultaneously for the front and back racks during the same pass of the basket **22**. An initialization sequence for basket **22'** may be controlled in a similar fashion.

According to some embodiments of the present invention, it may be desirable to affirmatively indicate to the scanners or sensors **36**, **37**, **36'** when there is no item present in a particular compartment. The doors **62'** of the compartments may be transparent to permit the bar code or other identifier on an item to be scanned through the door. When the basket **22** does not detect any item within the compartment, it may be configured to "jiggle" back and forth and/or up and down for a short period of time in order to increase the chances of scanning an item in the compartment. If no item is detected, then the controller may determine that no item is present in the compartment. According to some embodiments of the present invention, the controller then causes the basket **22** or **22'** to open that particular compartment, and to deliver any contents to the auxiliary bin **95**. According to some embodiments of the present invention, a special bar code or other indicator is placed on the top of the plate **100**, such that when an item is present in the compartment the item covers such special bar code or other indicator, such that the scanner scans only the item in the compartment, and such that when an item is not present in the compartment, the scanner scans the special bar code or other indicator which indicates that the compartment is empty. Such a special bar code or other indicator may alternatively be placed on the outside or inside of the door **62**, **62'**, and operate in a similar fashion.

FIG. **18** illustrates an automated retail system, according to embodiments of the present invention. A control system **102** is communicably coupled to the gantry system **104**, actuators or other machinery (e.g. actuators **32**, **32'**), and sensors and/or scanners or other sensing devices (e.g. **36**, **36'**, **37**, **61**, **63**, **70**, **93**, and **94**). The gantry system **104** may include rail system **16**, **18**, **20** and associated cables, motors, electronics, and other hardware for moving the delivery basket **22** along the horizontal axis x and the vertical axis y, according to embodiments of the present invention. Control system **102** may be a personal computer or other computing device, according to embodiments of the present invention.

The control system **102** is capable of executing instructions to perform the steps and methods described herein, in whatever order, and excluding one or more steps and/or including one or more additional steps or repetitions of steps, according to embodiments of the present invention. The control system **102** receives information or signals and, based on such information or signals, sends out control signals to cause the gantry system **104**, actuators **32**, **32'**, and other hardware to move accordingly, as described herein. The control system may also receive information from other hardware, not shown, for example a user interface touchscreen which receives selections from users of products to retrieve from compartments. The control system **102** may also rely on other sensors or signals not expressly shown, but which are apparent to one of ordinary skill in the art based on the present disclosure. For example, positional sensors may be used to provide the control system **102** with the two-dimensional (or three-dimensional) position of any piece of hardware described herein.

When a customer or requester indicates to the control system **102** that a particular product or item is desired, the control system **102** checks its database or listing of inventory based on its last scanning routine and/or initialization sequence. The control system **102** may find multiple matches for the product or the type of product requested. The control system **102** then controls the delivery basket **22** to send it, via the gantry system **104**, to a particular compartment holding the particular product that has been requested. According to embodiments of the present invention, the scanner **36**, **37** then scans the contents of the compartment again to verify again that the particular product is actually in the compartment. Systems which rely on manual and/or pre-positioned and/or pre-programmed inventory information do not have this capability, to confirm the presence and identity of the product just prior to dispensing. Once the product is verified, the door **62** to the compartment is opened, and the product is received in the delivery basket **22**, at which point it may then be scanned again, or a different kind of sensor may be used to sense that the product has entered the basket **22**, according to embodiments of the present invention. As such, embodiments of the present invention include an ability to determine the size, and layout of a customized grid of compartments, on one or both of a front compartment rack and a rear compartment rack, and scan and record/update the contents of each compartment. This may be done not only upon initialization or startup, but also after restocking, and also at any point in time. Also, individual compartments can be selectively scanned to confirm their contents, for example just prior to vending the product or otherwise opening the compartment's door. This automated inventory control reduces system errors, and also automates the process of taking inventory of the particular rack or racks or set of compartments.

FIG. **19** is an example of a computer system **200** with which embodiments of the present invention may be utilized. Computer system **200** represents an exemplary computer, which may operate as controller **102** in order to receive inputs (e.g. from sensors) and/or provide outputs (e.g. to control the gantry system and/or door actuator, among others). In this

simplified example, the computer system **200** comprises a bus **201** or other communication means for communicating data and control information, and one or more processing devices **202**, such as a well known processor, Application Specific Integrated Circuit (ASIC), a field programmable gate array (FPGA), or the like, coupled with bus **201**.

In this simplified embodiment, computer system **200** further comprises a random access memory (RAM) or other dynamic storage device (referred to as main memory **204**), coupled to bus **201** for storing information and instructions to be executed by processing device **202**. Main memory **204** also may be used for storing temporary variables or other intermediate information during execution of instructions by processor(s) **202**.

Computer system **200** can also include a read only memory (ROM) **206** and/or other static storage device coupled to bus **201** for storing static information and instructions for processing device **202**. A mass storage device **207**, such as a magnetic disk or optical disc and its corresponding drive, may also be coupled to bus **201** for storing instructions and information, such as configuration files, a key store and registration database, and the like.

One or more communication ports **203** may also be coupled to bus **201** for supporting network connections and communication of information to/from the computer system **200** by way of a communication network, such as a Local Area Network (LAN), Wide Area Network (WAN), or the Internet, for example. The communication ports **203** may include various combinations of well-known interfaces, such as one or more modems to provide network access, one or more 10/100 Ethernet ports, one or more Gigabit Ethernet ports (fiber and/or copper), or other well-known network interfaces commonly used in internetwork environments. In any event, in this manner, the computer system **200** may be coupled to a number of other network devices, communication devices, clients, NTMs, and/or servers via a conventional communication network infrastructure.

Optionally, operator and administrative interfaces (not shown), such as a display, keyboard, and a cursor control device, may also be coupled to bus **201** to support direct operator interaction with computer system **200**. Other operator and administrative interfaces can be provided through network connections connected through communication ports **203**. Finally, removable storage media (not shown), such as one or more external or removable hard drives, tapes, floppy disks, magneto-optical discs, compact disk-read-only memories (CD-ROMs), compact disk writable memories (CD-R, CD-RW), digital versatile discs or digital video discs (DVDs) (e.g., DVD-ROMs and DVD+RW), Zip disks, or USB memory devices, e.g., thumb drives or flash cards, may be coupled to bus **201** via corresponding drives, ports or slots.

Various modifications and additions can be made to the exemplary embodiments discussed without departing from the scope of the present invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the described features. Accordingly, the scope of the present invention is intended to embrace all such alternatives, modifications, and variations as fall within the scope of the claims, together with all equivalents thereof.

What is claimed is:

1. A system for automated retail comprising:

a product rack, the product rack comprising a plurality of compartments arranged along one or both of a horizontal axis and a vertical axis;

wherein at least one compartment of the plurality of compartments comprises a door configured to open and close the at least one compartment, wherein at least a portion of the door is substantially transparent;

a basket;

a gantry system, wherein the basket is movably coupled to the gantry system, wherein the gantry system is configured to position the basket adjacent to any of the plurality of compartments by moving the basket along one or both of the horizontal axis and the vertical axis; and

a scanner that moves with the basket, wherein the scanner is configured to identify a product within the at least one compartment or to determine that the at least one compartment is empty, and wherein a scanner signal of the scanner is configured to pass through the at least a portion of the door.

2. The system of claim **1**, wherein the basket does not have any component of movement along a direction that is substantially orthogonal to both the horizontal axis and the vertical axis.

3. The system of claim **1**, wherein the product rack is a first product rack, the system further comprising a second product rack, wherein the gantry system and basket are situated between the first and second product racks.

4. The system of claim **3**, wherein the basket and gantry system are configured to retrieve products from one or more compartments in the first product rack and one or more compartments in the second product rack.

5. The system of claim **1**, further comprising a delivery chute.

6. The system of claim **1**, further comprising a discard bin.

7. The system of claim **1**, further comprising a sensor configured to determine when the product enters the basket.

8. The system of claim **5**, further comprising a sensor configured to determine when the product enters the delivery chute.

9. The system of claim **1**, further comprising a door actuator, wherein the door actuator is configured to open the door upon movement of the basket along one or both of the horizontal axis and the vertical axis.

10. The system of claim **9**, wherein the door comprises a contact element, and wherein the door actuator is configured to open the door when the door actuator is pushed against the contact element.

11. The system of claim **9**, wherein the door actuator is extendable and retractable.

12. The system of claim **9**, wherein the door actuator is mounted to the basket.

13. The system of claim **1**, wherein the scanner is mounted adjacent to the basket.

14. The system of claim **1**, wherein the scanner is mounted on the basket.

15. The system of claim **1**, wherein the at least one compartment comprises a bottom that is at least partially sloped, wherein the bottom is configured to permit a product in the at least one compartment to slide out of the compartment when the door is opened.

16. The system of claim **15**, wherein a top of the basket is open to receive the product, and wherein a side wall of the basket closest to the product rack is at least partially sloped.

17. The system of claim **16**, further comprising a delivery chute, wherein the basket comprises a trap door configured to open when the basket is positioned above the delivery chute.

18. The system of claim **17**, wherein the delivery chute comprises a door actuator and the trap door comprises a

contact element, and wherein the trap door is configured to open when the contact element is lowered onto the door actuator.

19. A method for determining size and position of compartments in automated retail, the method comprising:

using a gantry system, moving a scanner along a product rack along a horizontal axis and a vertical axis;

recording a horizontal position and a width of each compartment or column of compartments of the product rack along the horizontal axis;

recording a vertical position and a height of each compartment or row of compartments of the product rack along the vertical axis;

scanning contents of each compartment of the product rack through a door on each compartment that is at least partially transparent.

20. The method of claim **19**, wherein scanning contents of each compartment of the product rack through the door on each compartment comprises scanning the contents of each compartment without opening the door.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,135,216 B2
APPLICATION NO. : 13/463616
DATED : September 15, 2015
INVENTOR(S) : Stark et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

In Column 6, Line 6, delete "racks 12,14" and insert -- racks 14, 12 --.

In Column 6, Line 49, delete "rack 13," and insert -- rack 15, --.

In Column 8, Line 63, delete "rack 14," and insert -- rack 12, --.

Signed and Sealed this
Third Day of May, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office